Name: Key

Chemistry 129.03 Spring 2017

General Chemistry

First Examination:

Equations, constants and periodic table are provided.

You may use a calculator.

Show all your work!

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Bonus: _____/2

Total: _____/100

1. (20%) Consider the reaction of $AgNO_3$ with Cu to produce Ag and $Cu(NO_3)_2$:

a) How many grams of $AgNO_3$ are needed to make 20.0mL of a 0.100M $AgNO_3$ solution?

$$\text{mol } AgNO_3 = (0.100\text{M } AgNO_3)(0.0200\text{L}) = 0.00200 \text{ mol } AgNO_3$$

$$0.00200 \text{ mol } AgNO_3 \left(\frac{169.88 \text{ g } AgNO_3}{1 \text{ mol } AgNO_3}\right) = 0.340 \text{ g } AgNO_3$$

b) Balance the chemical equation for this reaction. What type of reaction is this?

$$\underline{2}\ AgNO_3 + \underline{\quad}\ Cu \rightarrow \underline{2}\ Ag + \underline{\quad}\ Cu(NO_3)_2$$

Single Displacement

c) How many moles of Ag are produced when 20.0mL of a 0.100M $AgNO_3$ solution react with 0.1045g of Cu? Identify the limiting reagent.

$$0.00200 \text{ mol } AgNO_3 \left(\frac{2 \text{ mol Ag}}{2 \text{ moles } AgNO_3}\right) = 0.00200 \text{ mol Ag}$$

$$0.1045 \text{ g Cu} \left(\frac{1 \text{ mol Cu}}{63.55 \text{ g Cu}}\right)\left(\frac{2 \text{ mol Ag}}{1 \text{ mol Cu}}\right) = 0.03289 \text{ mol Ag}$$

$AgNO_3$ is the limiting reagent mol Ag produced: 0.00200 mol Ag

d) Calculate the theoretical yield in **grams**. If 0.1234 g of Ag are collected, what is the percent yield of the reaction?

$$0.00200 \text{ mol Ag} \left(\frac{107.87 \text{ g Ag}}{1 \text{ mol Ag}}\right) = 0.216 \text{ g Ag}$$

$$\% \text{ yield} = \frac{0.1234 \text{ g Ag}}{0.216 \text{ g Ag}} \times 100 = 57.1\%$$

2. (15%) Equilin contains C, H, and O. A 13.42g sample is burned and the following data are obtained: 39.61g CO_2 and 9.01g H_2O. Its molar mass is 268.34g/mol. Determine the empirical and molecular formulas of Equilin.

$$39.61\text{ g } CO_2\left(\frac{1\text{ mol } CO_2}{44.01\text{ g } CO_2}\right)\left(\frac{1\text{ mol C}}{1\text{ mol } CO_2}\right)\left(\frac{12.01\text{ g C}}{1\text{ mol C}}\right) = 10.809\text{ g C}$$

$$9.01\text{ g } H_2O\left(\frac{1\text{ mol } H_2O}{18.02\text{ g } H_2O}\right)\left(\frac{2\text{ mol H}}{1\text{ mol } H_2O}\right)\left(\frac{1.01\text{ g H}}{1\text{ mol H}}\right) = 1.01\text{ g H}$$

$$\text{mass O} = 13.42\text{g} - 10.809\text{g C} - 1.01\text{g H} = 1.601\text{ g O}$$

$$10.809\text{ g C}\left(\frac{1\text{ mol C}}{12.01\text{g C}}\right) = 0.9000\text{ mol C}$$

$$1.01\text{ g H}\left(\frac{1\text{ mol H}}{1.01\text{ g H}}\right) = 1.00\text{ mol H}$$

$$1.601\text{ g O}\left(\frac{1\text{ mol O}}{16.00\text{g O}}\right) = 0.1001\text{ mol O}$$

$$C_{\frac{0.9000}{0.1001}}H_{\frac{1.00}{0.1001}}O_{\frac{0.1001}{0.1001}}$$

$$\Downarrow$$

$$C_9H_{10}O$$

Empirical Formula (134.19 g/mol)

$$n = \frac{268.34\text{ g/mol}}{134.19\text{ g/mol}} \cong 2$$

Molecular Formula: $2\times(C_9H_{10}O) = C_{18}H_{20}O_2$

3. (10%) A hydrogen atom undergoes an electron transition from **n=5 to n=3.** (a) Does this transition correspond to absorption or emission of energy? (b) Determine the wavelength of light associated with this transition. (c) Identify the region of the electromagnetic spectrum to which it belongs.

(a) $n=5 \longrightarrow n=3$ Emission

(b) $\Delta E = -2.18\times10^{-18}\,J\left(\frac{1}{n_f^2}-\frac{1}{n_i^2}\right)$

$= -2.18\times10^{-18}\,J\left(\frac{1}{9}-\frac{1}{25}\right) = -1.55\times10^{-19}\,J$ ← emission

$\lambda = \frac{hc}{\Delta E} = \frac{(6.626\times10^{-34}\,J\cdot s)(3.00\times10^{8}\,m/s)}{1.55\times10^{-19}\,J} = 1.28\times10^{-6}\,m$

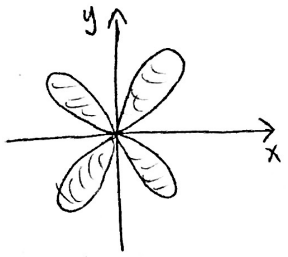
$= 1280\,nm$

(c) Infrared Region.

4. (10%) Fill in the gaps in the following table.

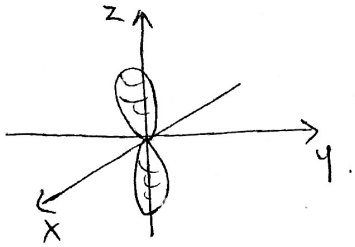
Name	Formula
cobalt (II) chlorate	$Co(ClO_3)_2$
xenon tetrafluoride	XeF_4
ammonium acetate	$NH_4C_2H_3O_2$
potassium permanganate	$KMnO_4$
dinitrogen tetroxide	N_2O_4
chromium (III) sulfite	$Cr_2(SO_3)_3$
calcium bromide	$CaBr_2$
hypochlorous acid	$HClO$
sodium hydrogen carbonate	$NaHCO_3$
sulfur dioxide	SO_2

(20%) i. Draw the following orbitals (shape and orientation): dxy, p_z and s orbitals. How many nodal planes does each orbital have?



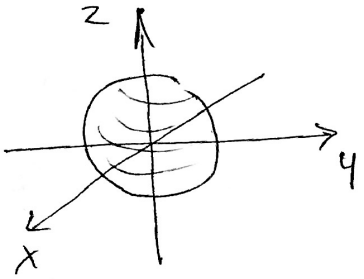
dxy

Two nodal planes



P_z

One nodal plane



S

No nodal planes

ii. What is the maximum number of electrons that can have of the following quantum numbers?

$n = 4,\ m_s = +\frac{1}{2}$ — 16 e^-s

$n = 3,\ l = 2$ — 10 e^-s

iii. Which of the following sets of quantum numbers is <u>allowed</u>? <u>Not allowed</u>?

$n = 1,\ l = 0,\ m_l = 0$ — allowed

$n = 3,\ l = -1,\ m_l = 1$ — not allowed

iv. Write the **full** and **condensed** electron configurations for **Fe**.

$1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^6$ ⟸ full ⇓ 26 e^-s

$[Ar] 4s^2 3d^6$ ⟸ condensed

6. (17%) Using the periodic table as a reference:

i. Which group in the periodic table has elements with high ionization energies and very negative electron affinities? What is the charge on the ions that these atoms form? Explain.

Group VII A : Halogens

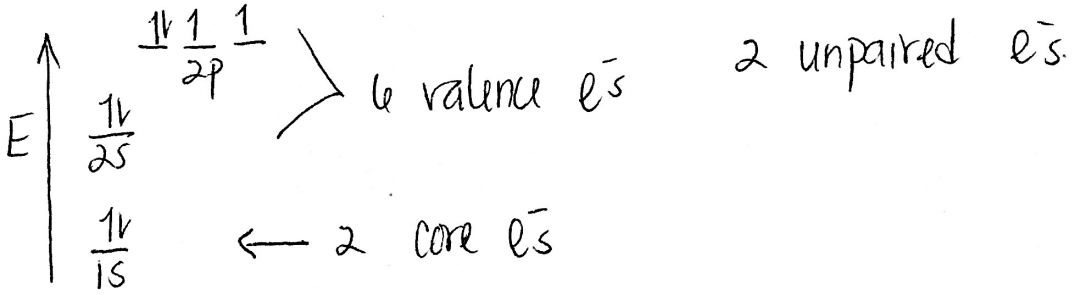
Halogens gain one electron to form −1 anions.

Halogens have very negative electron affinities which means they have a high tendency to gain electrons and very high ionization energies which means they have a low tendency to lose electrons. So, they gain one electron to form −1 anions and have a complete outershell.

ii. Arrange the following in order of **increasing** atomic radius:
Ne, F^-, Ga, Cs^+, F, Cs.

$$Ne < F < F^- < Ga < Cs^+ < Cs$$

iii. Draw the **atomic orbital energy diagram** of **oxygen** and show the number of valence electrons, core electrons and unpaired electrons. **Briefly** explain why the first ionization energy of oxygen is slightly lower than nitrogen's.



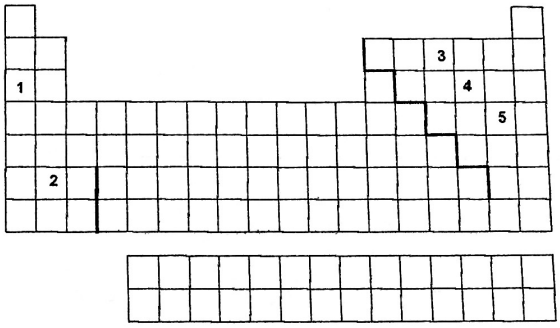
Oxygen's ionization energy is lower than that of nitrogen because removing one e^- from it would reduce the $e^- - e^-$ repulsions of two e^-s sharing the same orbital and would get a stable half-full 2p subshell.

7. (8%) Fill in the gaps in the following table.

Symbol	$^{24}_{12}Mg^{2+}$	$^{59}_{27}Co^{2+}$
Protons	12	27
Neutrons	12	32
Electrons	10	25
Mass Number	24	59
Charge	2+	2+

Bonus (2pts):

Five of the boxes of following periodic table are numbered. Predict the charge on the ion associated with each of these elements.



① +1

② +2

③ -3

④ -2

⑤ -1